How the Robots Made Billions Staging Market Attacks Like...

Goldman Sachs robots putting in two-share offers and buys. They’re offering to buy and sell at two different prices and seeing if anybody bites. While humans still decide how to invest, computers do the actual buying and selling, often in fractions of seconds.

Trade value:
Higher circles are larger trades

Nasdaq pinging servers

$2.2m
$230k
$25k
$2.7k
$300
60 Seconds of Chaos

San Francisco design firm Stamen teamed up with Nasdaq to visualize the frenzy of automated trading. This is one minute of bids and offers on March 8, 2011.

The olive, light yellow, blue, and burgundy circles represent orders sent to Nasdaq by Knight Capital, a large high-frequency trading firm.

Each color indicates a different stock.

- $2.7m
- $2.2m
- $250k
- $25k
- 1,000,000 shares
- 100,000
- 1,000
Steve Swanson was a typical 21-year-old computer nerd with a very atypical job. It was the summer of 1989, and he'd just earned a math degree from the College of Charleston. He tended toward T-shirts and flip-flops and liked Star Trek: The Next Generation. He also spent most of his time in the garage of his college statistics professor, Jim Hawkes, programming algorithms for what would become the world's first high-frequency trading firm, Automated Trading Desk. Hawkes had hit on an idea to make money on the stock market using predictive formulas designed by his friend David Whitcomb, who taught finance at Rutgers University. It was Swanson's job to turn Whitcomb's formulas into code. By tapping market data beamsed in through a satellite dish bolted to the roof of Hawkes's garage, the system could predict stock prices 30 to 60 seconds into the future and automatically jump in and out of trades. They named it BORG, which stood for Brokered Order Routing Gateway. It was also a reference to the evil alien race in Star Trek that absorbed entire species into its cybernetic hive mind.

Among the BORG's first prey were the market makers on the floors of the exchanges who manually posted offers to buy and sell stocks with handwritten tickets. Not only did ATD have a better idea of where prices were headed, it executed trades within one second—a snail's pace by today's standards, but far faster than what anyone else was doing then. Whenever a stock's price changed, ATD's computers would trade on the offers humans had entered in the exchange's order book before they could adjust them, and then moments later either buy or sell the shares back to them at the correct price. Bernie Madoff's firm was then Nasdaq's largest market maker. "Madoff hated us," says Whitcomb. "We ate his lunch in those days." On average, ATD made less than a penny on every share it traded, but it was trading hundreds of millions of shares a day. Eventually the firm moved out of Hawkes's garage and into a $36 million modernist campus on the swampy outskirts of Charleston, S.C., some 650 miles from Wall Street.

By 2006 the firm traded between 700 million and 800 million shares a day, accounting for upwards of 9 percent of all stock market volume in the U.S. And it wasn't alone anymore. A handful of other big electronic trading firms such as Getco, Knight Capital Group, and Citadel were on the scene, having grown out of the trading floors of the mercantile and futures exchanges in Chicago and the stock exchanges in New York. High-frequency trading was becoming more pervasive.

The definition of HFT varies, depending on whom you ask. Essentially, it's the use of automated strategies to churn through large volumes of orders in fractions of seconds. Some firms can trade in microseconds. (Usually, these shops are trading for themselves rather than clients.) And HFT isn't just for stocks: Speed traders have made inroads in futures, fixed income, and foreign currencies. Options, not so much.

Back in 2007, traditional trading firms were rushing to automate. That year, Citigroup bought ATD for $680 million. Swanson, then 40, was named head of Citi's entire electronic stock trading operation and charged with integrating ATD's systems into the bank globally.

By 2010, HFT accounted for more than 60 percent of all U.S. equity volume and seemed positioned to swell the rest. Swanson, tired of Citi's bureaucracy, left, and in mid-2011 opened his own HFT firm. The private equity firm Technology Cross-over Ventures gave him tens of millions to open a trading shop, which he called Eladon Partners. If things went well, TCW would kick in another multimillion-dollar round in 2012. But things didn't go well.

For the first time since its inception, high-frequency trading, the bogey machine of the markets, is in retreat. According to estimates from Rosenblatt Securities, as much as two-thirds of all stock trades in the U.S. from 2008 to 2011 were executed by high-frequency firms; today it's about half. In 2009, high-frequency traders moved about 3.25 billion shares a day. In 2012, it was 1.6 billion a day. Speed traders aren't just trading fewer shares, they're making less money on each trade. Average profits have fallen from about a tenth of a penny per share to a twentieth of a penny.

According to Rosenblatt, in 2009 the entire HFT industry made around $5 billion trading stocks. Last year it made closer to $1 billion. By comparison, JPMorgan Chase earned more than six times that in the first quarter of this year. The "profits have collapsed," says Mark Gorton, the founder of Tower Research Capital, one of the largest and fastest high-frequency trading firms. "The easy money's gone. We're doing more things better than ever before and making less money doing it."

"The margins on trades have gotten to the point where it's not even paying the bills for a lot of firms," says Raj Fernando, chief executive officer and founder of Chopper Trading, a large firm in Chicago that uses high-frequency strategies. "No one's laughing while running to the bank now, that's for sure." A number of high-frequency shops have shut down in the past year. According to Fernando, many asked Chopper to buy them before going out of business. He declined in every instance.

One of HFT's objectives has always been to make the market more efficient. Speed traders have done such an excellent job of wringing waste out of buying and selling stocks that they're having a hard time making money themselves. HFT also lacks the two things it needs the most: trading volume and price volatility. Compared with the deep, choppy waters of 2009 and 2010, the stock market is now a shallow, placid pool. Trading volumes in U.S. equities are around 6 billion shares a day, roughly where they were in 2006. Volatility, a measure of the extent to which a share's price jumps around, is about half what it was a few years ago. By seeking out price disparities across assets and exchanges, speed traders ensure that when prices do get out of whack, they're quickly brought back into harmony. As a result, they tamp down volatility, suffocating their two most common strategies: market making and statistical arbitrage.

Market-making firms facilitate trading by quoting both a bid and a sell price. They profit off the spread in between, which these days is rarely more than a penny per share, so they rely on volume to make money. Arbitrage firms take advantage of small price differences between related assets. If shares of Apple are trading for slightly different prices across any of the 13 U.S. stock exchanges, HFT firms will buy the cheaper shares or sell the more expensive ones. The more prices change, the more chances there are for disparities to ripple through the market. As things have calmed, arbitrage trading has become less profitable.

To some extent, the drop in volume may be the result of high-frequency trading scaring investors away from stocks, particularly after the so-called Flash Crash of May 6, 2010, when a big futures sell order filled by computers unleashed a massive selloff. The Dow Jones industrial average dropped 600 points in about five minutes. As volatility spiked, most high-frequency traders that stayed in the market that day made a fortune. Those that turned their machines off were blamed for accelerating the selloff by drying up liquidity, since there were fewer speed traders willing to buy all those cascading sell orders triggered by falling prices.

For two years, the Flash Crash was HFT's biggest black eye. Then last August, Knight Capital crippled itself. Traders have taken to calling the implosion "theKnightmare." Until about 9:30 a.m. on the morning of Aug. 1, 2012, Knight was arguably one of the kings of HFT and the largest trader of U.S. stocks. It accounted for 17 percent of all trading volume in New York Stock Exchange-listed stocks, and about 16 percent in Nasdaq listings among securities firms.
Race to the Starting Line

In the hours before the opening bell rings at 9:30, trading algorithms ping Nasdaq with a range of buy and sell orders to test prices. Most orders are canceled and never result in a trade.

7:00-7:01 a.m.
Pre-market activity is still relatively light. Most buy and sell orders are more than $25,000.

8:30-8:31 a.m.
Volume picks up as computers send smaller bids and offers to Nasdaq, with the exception of a few bursts like this one at 8:30.

9:30-9:31 a.m.
Within 30 seconds of the market opening, a torrent of buy and sell orders floods Nasdaq's servers. By now, computers have two hours of data on where prices are probably headed. With the market open, the blue buy orders tend to be for higher prices than offers to sell.

Orders to buy and sell large blocks of shares for low prices are being put in within milliseconds of one another.
When the market opened on Aug. 1, a new piece of trading software that Knight had just installed went haywire and started aggressively buying shares in 140 NYSE-listed stocks. Over about 45 minutes that morning, Knight accidentally bought and sold $7 billion worth of shares—about $2.6 million a second. Each time it bought, Knight's algorithm would raise the price it was offering into the market. Other firms were happy to sell to it at those prices. By the end of Aug. 2, Knight had spent $440 million unwinding its trades, or about 40 percent of the company's value before the glitch.

Knight is being acquired by Chicago-based Getco, one of the leading high-frequency market-making firms, and for years considered among the fastest. The match, however, is one of two ailing titans. On April 15, Getco revealed that its profits had plunged 90 percent last year. With 409 employees, it made just $16 million in 2012, compared with $163 million in 2011 and $430 million in 2008. Getco and Knight declined to comment for this story.

Getco's woes say a lot about another wound to high-frequency trading: Speed doesn't pay like it used to. Firms have spent millions to maintain millisecond advantages by constantly updating their computers and paying steep fees to have their servers placed next to those of the exchanges in big data centers. Once exchanges saw how valuable those thousandths of a second were, they raised fees to locate next to them. They've also hiked the prices of their data feeds. As firms spend millions trying to shave milliseconds off execution times, the market has sped up but the racers have stayed even. The result: smaller profits. "Speed has been commoditized," says Bernie Dan, CEO of Chicago-based Sun Trading, one of the largest high-frequency market-making trading firms.

No one knows that better than Steve Swanson. By the time he left Citi in 2010, HFT had become a crowded space. As more firms flooded the market with their high-speed algorithms, all of them hunting out inefficiencies, it became harder to make money—especially since trading volumes were steadily declining as investors pulled out of stocks and poured their money into bonds. Swanson was competing for shrinking profits against hundreds of other speed traders who were just as fast and just as smart. In September 2012, TCV decided not to invest in the final round. A month later, Swanson pulled the plug.

Even as the money has dried up and HFT's presence has declined, the regulators are arriving in force. In January, Gregg Berman, a Princeton-trained physicist who's worked at the Securities and Exchange Commission since 2009, was promoted to lead the SEC's newly created Office of Analytics and Research. His primary task is to give the SEC its first view into what high-frequency traders are actually doing. Until now the agency relied on the industry, and sometimes even the financial blogosphere, to learn how speed traders operated. In the months after the Flash Crash, Berman met with dozens of trading firms, including HFT firms. He was amazed at how much trading data they had, and how much better their view of the market was than his. He realized that he needed better systems and technologies—and that the best place to get them was from the speed traders themselves.

Last fall the SEC said it would pay Tradeworx, a high-frequency trading firm, $2.5 million to use its data collection system as the basic platform for a new surveillance operation. Code-named Midas (Market Information Data Analytics System), it scourrs the market for data from all 13 public exchanges.

Midas went live in February. The SEC can now detect anomalous situations in the market, such as a trader spamming an exchange with thousands of fake orders, before they show up on blogs like Naked Capitalism and Zero Hedge. If Midas sees something odd, Berman's team can look at trading data on a deeper level, millisecond by millisecond. About 100 people across the SEC use Midas, including a core group of quants, developers, programmers, and Berman himself. "Around the office, Gregg's group is known as the League of Extraordinary Gentlemen," said Brian Bussey, associate director for derivatives policy and trading practices at the SEC, during a panel in February. "And it is one group that is not made up of lawyers, but instead actual market and research experts." It's early, but there's evidence that Midas has detected some nefarious stuff. In March the Financial Times reported that the SEC is sharing information with the FBI to probe manipulative trading practices by some HFT firms. The SEC declined to comment.

On March 12, the day the Futures Industry Association annual meeting kicked off at the Boca Raton Resort & Club, regulators from the U.S. Commodity Futures Trading Commission, and also from Europe, Canada, and Asia, gathered in a closed-door meeting. At the top of the agenda was "High-Frequency Trading—Controlling the Risks." Europeans are already clamping down on speed traders. France and Italy have both implemented some version of a trading tax. The European Commission is debating a euro zone-wide transaction fee.

In the U.S., Bart Chilton, a commissioner of the CFTC, has discussed adding yet more pressure. At the Boca conference the evening after the meeting took place, sitting at a table on a pink veranda, he explained his recent concern. According to Chilton, the CFTC has uncovered some "curious activity" in the markets that is "deeply disturbing and may be against the law." Chilton, who calls the high-frequency traders "cheetahs," said the CFTC needs to rethink how it determines whether a firm is manipulating markets.

Under the CFTC's manipulation standard, a firm has to have a large share of a particular market to be deemed big enough to engage in manipulative behavior. For example, a firm that owns 20 percent of a company's stock might be able to manipulate it. Since they rarely hold a position longer than several seconds, speed traders might have at most 1 percent or 2 percent of a market, but due to the outside influence of their speed, they can often affect prices just as much as those with bigger footprints—particularly when they engage in what Chilton refers to as "feeding frenzies," when prices are volatile. "We may need to lower the bar in regard to cheetahs," says Chilton. "The question is whether revising that standard might be a way for us to catch cheetahs manipulating the market."

Recently the CFTC has deployed its own high-tech surveillance system, capable of viewing market activity in hundreds of a second, and also tracing trades back to the firms that execute them. This has led the CFTC to look into potential manipulation in the natural gas markets and review something called "wash trading," where firms illegally trade with themselves to create the impression of activity that doesn't really exist.

In May, Chilton proposed a .06% fee on futures and swaps trades. The tax is meant to calm the market and fund CFTC investigations. Democrats in Congress would go further. Iowa Senator Tom Harkin and Oregon Representative Peter DeFazio want a .03% percent tax on nearly every trade in nearly every market in the U.S.

As profits have shrunk, more HFT firms are resorting to something called momentum trading. Using methods similar to what Swanson helped pioneer 25 years ago, momentum traders sense the way the market is going and bet big. It can be lucrative, and it comes with enormous risks. Other HFTs are using sophisticated programs to analyze news wires and headlines to get their returns. A few are even scanning Twitter feeds, as evidenced by the sudden selloff that followed the Associated Press's hacked Twitter account reporting explosions at the White House on April 23. In many ways, it was the best they could do.
"The Knightmare"


1. Market opens
Spansion's share price peaks at $11.46 at 9:31 a.m.

2. Knight starts trading
Seconds after the markets open, Knight's algorithm begins its Spansion share-dumping frenzy, pushing the price below $10.

3. First halt
NYSE, the venue for most Spansion trades, sees something is wrong and suspends trading of the stock for a few minutes. Spansion's price climbs on other exchanges as the dumping pauses.

4. Second halt
The pause ends, and Knight's rogue algorithm springs back into action before NYSE calls another halt.

5. Final halt
At 9:58 a.m., NYSE finally stops Knight's trading for the day. Spansion's stock, freed of Knight's algorithm, resumes a normal trading pattern.

6. Price rebound
The stock returns slightly shy of its earlier peak. The price then falls as traders unload the stock they bought so cheaply before.